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Exploitation of geothermal energy as a priority of sustainable energetic development in Serbia

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ABSTRACT

The actual global economic crisis, including all other well-known problems of sustainable development, reflects the direction of development of all countries in the world. Serbia, as a European country in its early stage of development, is trying to synchronize its progress with experience of other countries from the field of sustainable development and in accordance with rules in the field of energetic and energetic efficiency, and, as well as to promote and develop the sector of use of renewable sources of energy. On the other hand, Serbia is a country which largely depends on import of all forms of energy, which to a great extent affects its economic stability. Therefore, in Serbia the strategy for development of energetic was imposed and it considers all the aspects of development of energetic until 2015 and it also defines the priorities which can be mostly seen in the choice of forms of alternative sources of energy. These sources, based on some criteria, can be considered the most convenient for a gradual substitution of energy which is gotten from the conventional sources. Taking into account strategically defined goals and domestic potentials which are at disposal, as well as economic parameters, an alternative source of energy of basic importance for the future exploitation on the territory of Serbia geothermal energy, was chosen. The research points to the fact that Serbia will be capable to respond adequately to Kyoto protocol demands and to the European rules regarding the substitution of a certain amounts of fossil fuels by the fuel origin from the raw biological materials. The research defines the existent and non-existent capacities and the assessment of positive effects of usage of geothermal energy. At the moment, 160 long holes are being exploited whose water temperature is around 60 °C (140 °F) and their heat power reach 160 MJ/s. It was stated that adequate exploitation of existing and new geothermal sources a yearly would save about 500,000 tons of fossil fuels what is proportional to the 10% of the today's heating system. The total amount of heat accumulated at geothermal deposit sites in Serbia, up to 3 km of depth, is two times greater than the total amount of heat that may be generated by burring all available coal reserves in Serbia. Price of electrical energy produced from geothermal springs is estimated to be between 9.2 US cents/kWh and 11.5 US cents/kWh. In order to support exploitation of geothermal energy (as well as all other renewable sources of energy) the decision that all the producers of energy from renewable sources get a status of privileged producers were made.

Contents

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1. Introduction

For a number of years now, Serbia has an energy deficit, which is growing. Serbia is an energy-wise medium-dependent country. The annual consumption of all types of energy is grater than domestic production, what makes the total dependence of around forty percent. At the same time one should bear in mind the fact that the level of economic development is still below the level that is necessary for speedy approaching drawing closer to development countries and that the needs for energy will only increase. It is impermissible for Serbia today to consume three to five times more energy per every euro of the GDP than UNECE countries.

Serbia has god investment potentials in renewable energy sources such as solar energy, wind and geothermal energy or the hydro-potential of small water courses. The largest reserves perhaps lie in the enormous potential of geothermal resources, biomass and biogas. However, the awareness about this is still not sufficiently developed, and there is an insufficient amount of investment funds to launch an investment cycle in this field, even though, at the same time large foreign currency funds are being spent on imports of the lacking energy [1].

Serbia ratified Kyoto protocol in September 2007 and it thus, demonstrated its readiness to implement measures aimed at preserving the environment. In the area of the common agricultural policy and the rural development policy, Agenda 2000 [10,11] invites member states to encourage renewable energy sources. The key recommendation of the European Conference on Renewable Energy was that the European Union should set a new medium-term target: renewable sources should satisfy at least 20% of energy consumption by the year 2020.

In order to resolve systematically the problem of energetic deficit and to synchronize the development with the demands of ratified international contracts, Serbia adopted a row of basic developmental documents which clearly point to necessity of sustainable managing of energetic resources [2], as for economically good position and international integrations so as in order to preserve the citizens' health. By defining the strategy of sustainable development, there was accepted the principle of need for adequate conceptualizing of relations between development of economy and preservation of natural and by that energetic resources [3].

2. Methodology of research

While conceptualizing the strategies for development of energetic sector in Serbia (in the region of Vojvodina) there was a precise vision and mission and based on that were made some of the main aims of strategy for development in this sector [4]. After the strategic conceptualizing, the phase of strategic analysis – which had as an aim to establish the state in internal and external surroundings – was conducted. By doing so it would be possible to set further aims and define the activities which are necessary for their realization. Given that one of the basic strategic aims of development of energetic sector is partial directing to the renewable sources of energy there was an all-inclusive research which had to establish the following:

- available potentials of certain renewable sources of energy;
- economic profit of getting the energy from different renewable sources;
- geothermal characteristic of Serbia;
- the potential of geothermal energy in Serbia.

This research covered all renewable sources of energy available at the territory of Vojvodina (biomass, hydropower, wind, solar and geothermal energy) [5]. The research was supposed to determine two renewable sources of energy which had the biggest potential to be taken into account while programming the future investments.

3. Results of research

3.1. Available potentials of certain renewable sources of energy

After the research there have been determined the following basic indicators in the field of temporary potential of all renewable sources of energy in Serbia:

- around 2.4 MTOE (million tons of oil equivalent) a year (i.e. around 62%) of the whole potential is in the exploitation of the biomass, 1 MTOE of which makes the potential of wood biomass (felling of the trees or wood waste mass during its primary and/or industrial processing) and more than 1.4 MTOE is made of agricultural biomass [6–8].
- Around 0.4 MTOE a year (10.4% of the whole potential) are found in small streams where the smaller hydro-electric power stations can be built. This estimation is based on the land register of small hydro-electric power stations where there are 856 locations suitable for building small power stations of 90 kW to 8.5 MW, of the whole power of 450 MW and 1590 GW by which around 90% of locations have the technical potential under 1 MW.
- Around 0.2 MTOE a year (around 5.2% of the whole potential) is in the existent geothermal springs which are for the most part located on the territory of Vojvodina. At the moment 160 long holes are being exploited and their water temperature is around 60 °C (140 °F) and their heat power reach 160 MJ/s even if all the research show that the mentioned potential is at least five times bigger than the existent one [11].
- Around 1.9 MTOE a year (around 5% of the whole potential) is found in the energy of wind which is based on the long-term data of the existent hydro-meteorological stations which carry out the measuring on 10 m altitude and it is also based on the new data of the measuring which were carried out on 100 m altitude [12].
- Around 0.64 MTOE a year (around 16.7% of the whole potential) is found in the exploitation of solar energy, including the fact that in Serbia the number of hours of Sun is much higher than in some other European countries and it is around 2000 h per year.

3.2. Economic profit of getting the energy from different renewable sources

After determining the existent potential of renewable sources of energy the criteria of their economic profit by using the compensational rates [9,10] and it can be shown in the following way:

- Electrical energy gotten by the power of wind: 6.19 Euro-cents/kWh to 9.10 Euro-cents/kWh (7.9 US cents/kWh and 11.7 US cents/kWh).
- Electrical energy gotten from photovoltaic systems, since the year 2002: min 48.1 Euro-cents/kWh (61.7 US cents/kWh).
- Electrical energy produced in hydro-electric power stations: min 7.76 Euro-cents/kWh (9.9 US cents/kWh).
- Electrical energy produced by burning the biomass: 8.70 Euro-cents/kWh to 10.23 Euro-cents/kWh (11.2 US cents/kWh and 13.1 US cents/kWh).
- Electrical energy gotten from geothermal springs–7.16 Euro-cents/kWh to 8.95 Euro-cents/kWh (9.2 US cents/kWh and 11.5 US cents/kWh).

Based on the first results of the research of economic and estimated energetic effects of exploitation of energy which can be

obtained from renewable sources the availability of geothermal water resources was in detail considered as an alternatively the most acceptable form of renewable energy.

3.3. Geothermal characteristic of Serbia

The geothermal characteristic of Serbia are very interesting because of the origin and of the usage (Fig. 1Map 1). There are four groups of reservoirs which are categorised by depth [11].

The first group of reservoirs have a maximum thickness of 2000 m. The highest water temperature is 120 °C (248 °F). The average flowing well-yields are 1–3 l/s.

The second group of reservoirs are in Lower Pliocene and Pannonian sediments, composed of seadstones of a lower porosity than the aquifers of the first group. The maximum expected water temperature in this group is up to 120 °C. Average yields of flowing wells are 2.5–5 l/s and the well-head water temperature are 50–60 °C.

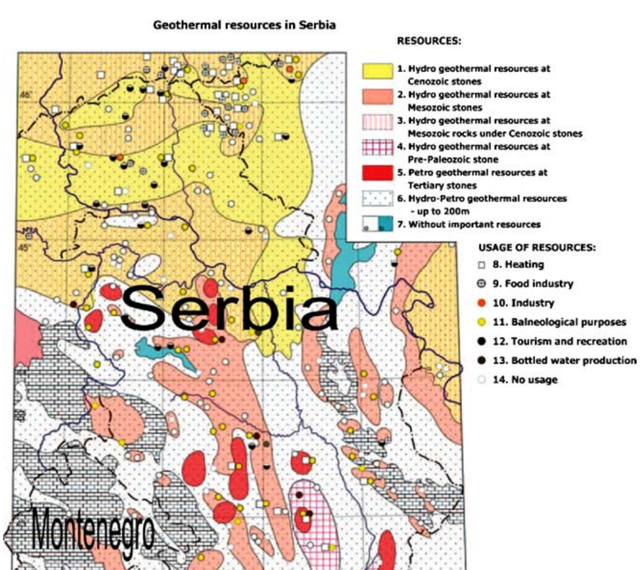
The third group are those of Neogene and Paleogene sediments. These are Miocene limestones, sandstones, basal conglomerates and basal breccias. Average well-yields are 5–10 l/s and water temperature well-heads are 40–60 °C.

The fourth group of reservoirs are Mesozoic and Paleozoic rocks under Paleogene and Neogene sediments. Average well-yields is 12 l/s or 40 l/s from reservoirs near the basin's margin. The water temperature at well-heads are mostly 40–60 °C.

3.4. The potential of geothermal energy in Serbia

Following the detailed insight and analyses of the results of research, including the estimations of necessary means for investment and the period to profit from investing into certain sources of energy there was also determined by the strategy for development of energetic sector that the geothermal energy as a whole can be considered the priority renewable source of energy on the territory of Vojvodina and Serbia in general.

Mineral and thermal waters of the Vojvodina have been known for centuries. Records indicate that they were used by ancient Romans and later by the Turks. The first drilling of artesian



Map 1. Geothermal resources in Serbia.

wells in the more recent history in 1848. The depths of first wells were as much as 400 m, and some of them have been used every since.

Geothermal characteristic of Serbia are a consequence of geological composition of the terrain and hydrological and geothermal characteristic of the landscape. More complete knowledge about geothermal potentials of drills has started to accumulate since 1949. In the period form 1969 to 1996, 73 drills were bored with then overall depth of 62,678.60 m. The most intensive researches were implemented in the 80 s of the last century when 45 drills were bored with the total depth of 34,840 m or approximately 56% of all drills [12].

The territory of Vojvodina as a part of Panonian basin belongs to the large European geothermal zone which has favorable conditions for researches and utilization in filed of geothermal energy. For the time being, hydrothermal energy is investigated and utilized. This concerns thermal waters of natural springs and waters in rocky masses which can be accessed by drilling. In Vojvodina for hydrogeological systems are recognized and classified. There basic characteristic of investigated and defined: ethological composition, stratigraphic references, type an quality of rock collectors, temperature and hydrodynamic features, physical and chemical features of terminal and thermomineral waters and accompanying released gases.

Geothermal flow density represents the main parameter used to estimate the geothermal potential at the certain location. This parameter represents the amount of thermal energy flowing each second through the area of 1 m^2 of the earth's interior and reaching the surface of the earth. The value of this parameter in Serbia is mostly higher than 60 mW/m^2, which represents the average value of flow density in Europe. The highest values of this parameter are at Vojvodina, northern part of Serbia [13,14].

Generally speaking, geothermal waters suitable for use are accumulated in all systems. However, their temperature, profusion, collector properties, chemical composition, gaseous factor and other characteristics are decisive for determining future prospects and particular conditions for exploitation. This is the reason why each drill should be individually investigated in that detail when making decision concerning the choice of exploitation manner and the most suitable equipment.

Research is provided at 73 geothermal drills, deepest was at 2520 m, and shallowest at 305 m. General picture of important and relevant characteristic of geothermal water in Serbia are [15,16]:

- drills are mainly self-outflow operated and most frequent water profusion is 10–20 l/s;
- most frequent outflow temperature is 40–60 °C;
- geothermal gradients are 4.5 °C/100 m to 7.5 °C/100 m;
- nearly all waters contain certain quantities of gases, mostly methane;
- waters contain dissolved minerals in the range 0.42–13.94 g/l;
- mineral contents in drills bored for oil and gas are 0.40–40.18 g/l.

Overall heat energy of hydrothermal drills water cooling to 15 °C which included 65 drills was 85,605 kW. Only 23 of them have been triggered for the production of heat energy.

Exploitation of geothermal resources in Vojvodina is restricted to traditional methods which means for therapeutic and recreational purposes. The water from two from these borings is used to grow produce at greenhouses, three borings are used for farm heating, three are used for heating commercial buildings, two are connected to leather and textile facilities while thirteen borings are used for balneological purposes [15].

Outside region of Vojvodina, geothermal water resources are used for heating purposes at greenhouses, a poultry farm, industrial facilities and buildings of the rehabilitation and tourist

Table 1
Exploitation of hydro geothermal resources according to function type.

Function	Installed thermal power (MW)	Produced heat (TJ/year)
Residential and commercial areas (direct use)	18.5	575
Spas and recreation	36.0	1150
Grain drying	0.7	22
Greenhouses	8.4	256
Fishing and cattle breeding	6.4	211
Industrial processes	3.9	121
Heat pump heating	12.0	80
Total	86.0	2415

centers. Exploitation of hydro geothermal resources according to function type in Serbia is presented in Table 1:

There is considerable potential for geothermal energy installation in Serbia that may be used for residential, institutional and industrial applications, which could replace the use of at least 500,000 tons of imported fuels annually.

4. Conclusion

Based on the strategy for development of energetic in Serbia as well as in accordance to the defined vision of sustainable development of the country, there was a research conducted to find out the availability of alternative sources of energy in the territory of Serbia. Furthermore, in accordance to the conclusion, there were defined short-term and long-term priorities for development of energetic sector, and above all, among those are reconstruction of the existent energetic plants and measures and activities necessary to increase energetic efficiency.

Considering the results obtained from this research and using the criteria of availability, economic and ecological justifications, geothermal energy can be considered a renewable source energy which is the most appropriate one for Serbia. There are some measures which are foresighted and by which all the producers of energy from the renewable sources will have the special status – status of privileged producers. They are entitled to subsidies, tax and costume relief, priority on the organized electrical power market over other producers who offer electrical power under equal conditions.

Exploitation of geothermal energy which is chosen as primary type of renewable energy sources in Serbia is an unjustly low level talking into account the abundance of resource locations, some of which are ranked among the most affluent in Europe. With relatively small investments, compared to conventional imported and environmentally unclean fuels and domestic fuels, geothermal energy and bio fuels, in next 10 years, may cover 10% the total heating requirements in Serbia, and so replace the use of at least 500,000 tons of imported fuels annually.

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